OBSERVER REVIEW

A COLLECTION OF STUDIES ANALYZING CORRELATIONS ON THE SUN'S EFFECT ON TECHNOLOGY & ELECTRONICS

OBSERVER REVIEW

STARLINK DISRUPTIONS FROM SOLAR ACTIVITY

BY: BEN DAVIDSON

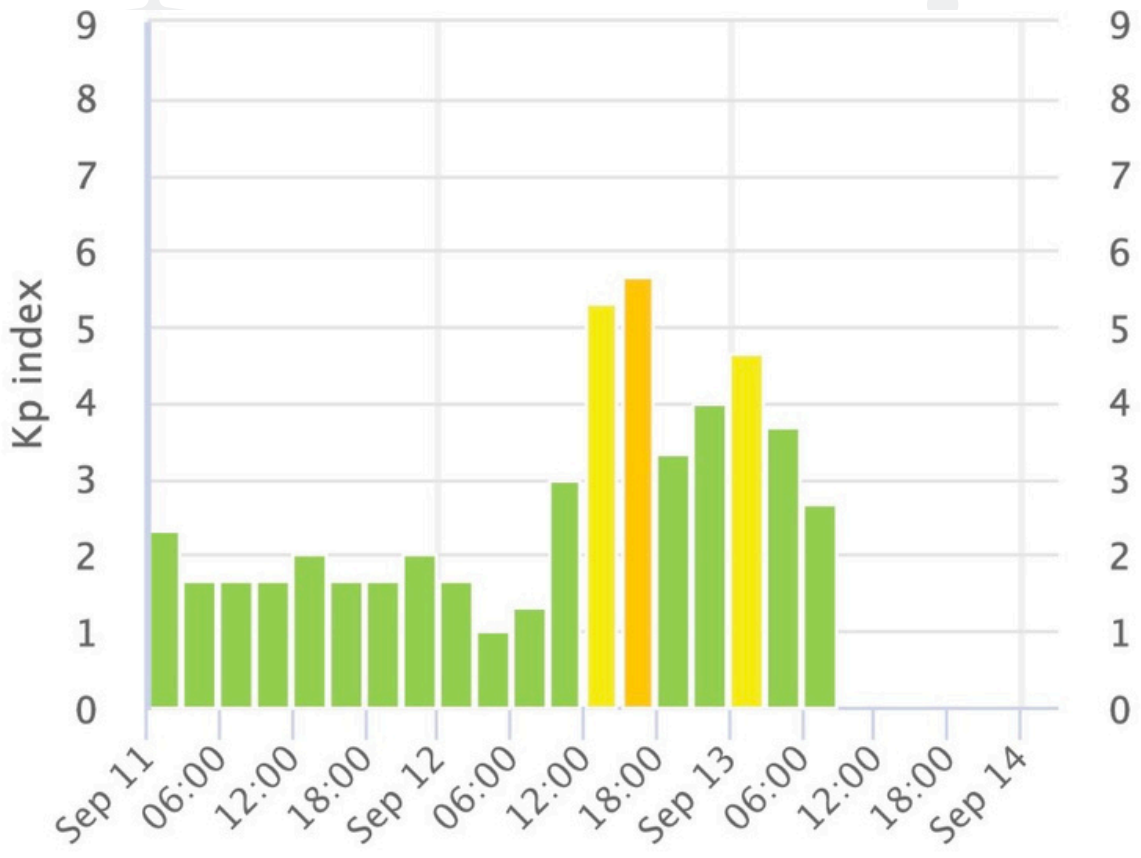
ARTICLE REFERENCED:
ELON MUSK'S SPACEX LOST 200 STARLINK SATELLITES IN TWO MONTHS, AND NOBODY KNOWS WHY

BACKGROUND:

EARTH'S WEAKENING MAGNETIC FIELD HAS BEEN MAKING OUR PLANET MORE AND MORE VULNERABLE TO LESSER AND LESSER SPACE WEATHER.

WE HAVE SEEN EXTREMELY UNEXPECTED AURORAL OUTBURSTS FROM LESS-THAN-EXTREME SPACE WEATHER, AND WE HAVE SEEN THE STARLINK SATELLITES HAVE AN EXCEPTIONAL VULNERABILITY GIVEN THEIR UNIQUE ORBITAL ALTITUDE.

WE HAVE SAID THAT THESE MAY BE THE TECHNOLOGICAL PUZZLE PIECE TO WATCH FOR INCREASED PROGRESS IN THE MAGNETIC EXCURSION OF EARTH, AND PLANETARY VULNERABILITY.



NEW SCIENCE:

IN MID-SEPTEMBER, A MILD GEOMAGNETIC STORM (IMAGE) WAS PERFECTLY TIMED WITH A NEAR-GLOBAL OUTAGE IN THE STARLINK NETWORK.

THE ISSUE WAS QUICKLY FIXED, BUT NO OFFICIAL EXPLANATION WAS EVER GIVEN TO THE PUBLIC; IT IS LIKELY THAT THE SOLAR STORM IMPACTED THE PERFORMANCE OF THE SATELLITES.

IT WAS ALSO ANNOUNCED THAT STARLINK HAD LOST A RECORD NUMBER OF SATELLITES THIS YEAR, DURING THE SAME PERIOD WHEN THAT SEEMINGLY UNDERWHELMING SPACE WEATHER WAS PRODUCING UNEXPECTEDLY STRONG AURORAL DISPLAYS.

SIGNIFICANCE:

IT APPEARS VERY LIKELY THAT THE STARLINK SATELLITES ARE THE "CANARY IN THE COAL MINE" THAT WE HAD BELIEVED THEM TO BE. THEIR UNIQUE ORBIT PUTS THEM AT DIRECT RISK FROM SEVERAL OF THE IMPACTS OF A SOLAR STORM, INCLUDING THE ENERGETIC DISRUPTION AND THE EXTRA DRAG OF ATMOSPHERIC INFLATION.

THEY CONTINUE TO HAVE PROBLEMS DURING GEOMAGNETIC EVENTS, TO A DEGREE FAR MORE FREQUENT AND SEVERE THAN WOULD BE EXPECTED GIVEN THE HISTORICAL SPACE WEATHER PARADIGM.

WE MUST CONCLUDE THAT THEY ARE AN EXCELLENT BAROMETER OF THE EARTH'S VULNERABILITY TO SOLAR ACTIVITY AS THE PROTECTIVE MAGNETIC FIELD CONTINUES WEAKENING IN THE ONGOING EXCURSION AND POLE SHIFT.

ESTIMATING CARRINGTON-LEVEL TECH IMPACTS

BY: BEN DAVIDSON

ARTICLE REFERENCED:
MAGNITUDE ESTIMATES FOR THE CARRINGTON FLARE IN 1859 SEPTEMBER: AS SEEN FROM THE ORIGINAL RECORDS

BACKGROUND:

We know that the sun released super flare level eruptions on fairly regular cycles. Every 150-200 years there is an X50 to X100 level flare, every 1500 years there is an X100+ event, every 3000 years there is an X500+ event, and every 6000 years there is an ~X1000 event. We know that the 1859 Carrington event was one of the 150-200-year events, but most estimates put it around X40. This would put the Carrington event on a similar level to the great flares of 1921, 1989, and 2003, which is problematic for the cycle and frequency of the events.

NEW SCIENCE:

The latest estimate of the Carrington Event flare is X80, with a range that possibly reaches up to X125, making it far greater than anything seen in the satellite era.

RELEVANCE:

THE NEW ESTIMATE HELPS CLEAN-UP THE MATH ON HOW OFTEN THE SUN UNLEASHES THESE POWERFUL SUPER FLARES. WE CAN NOW SUGGEST THAT AN X30 TO X45 OCCURS APPROXIMATELY EVERY 30 TO 50 YEARS, WITH A CARRINGTON LEVEL FLARE (~X80) ON THE 150-200 YEAR CYCLE WE SEE IN THE GEOLOGIC DATA. THIS MEANS THAT DURING THE TIME OF MODERN SCIENCE, WE HAVE NOT SEEN ANYTHING EVEN REMOTELY CLOSE TO THE CARRINGTON EVENT POWER OF THE SUN.

AN X80 FLARE WOULD CERTAINLY CAUSE GLOBAL DEVASTATION OF THE POWER GRIDS AND TELECOMMUNICATIONS, WHILE IT IS CONCEIVABLE THAT AN X40 COULD HAVE ONLY REGIONAL IMPACTS.

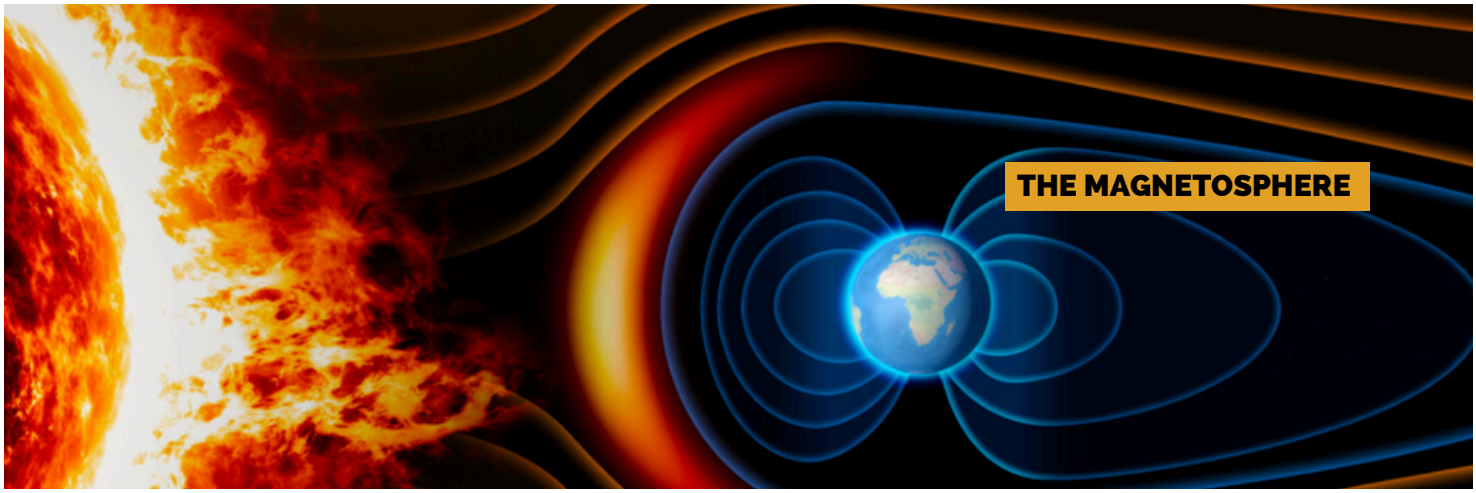
SOLAR STORMS AND GROUND-LEVEL EM EFFECTS

BY: BAILEY LAURISSA

ARTICLE REFERENCED:
CHAOTIC VARIABILITY OF THE MAGNETIC FIELD AT EARTH'S SURFACE DRIVEN BY IONOSPHERIC AND SPACE PLASMAS

As we know, solar storms, caused by eruptions on the Sun's surface, release massive amounts of charged particles that travel through space and interact with Earth's magnetosphere. This interaction can create geomagnetic storms, which in turn cause fluctuations in the magnetic field at Earth's surface. We discuss daily that these variations have real-world consequences, affecting power grids, GPS signals, and communication systems.

The Sun and its interaction with Earth's magnetosphere produce changes that occur on a scale of hours to years. This study confirms that external sources dominate magnetic field variations over shorter timeframes, particularly during solar storms.



To explain these fluctuations, researchers have used a concept called magnetic helicity, which describes how twisted and interwoven magnetic field lines become over time. Data collected from spacecraft such as the Solar Dynamics Observatory, the Wind spacecraft, and the Swarm satellite have allowed scientists to analyze how the Sun's activity influences Earth's magnetic environment.

A key finding is that the chaotic interactions between solar wind, Earth's magnetosphere, and the ionosphere follow a pattern described by the Kolmogorov-Iroshnikov turbulence model. This model explains how energy is transferred through different scales, leading to unpredictable yet structured fluctuations in the magnetic field.

WHAT IS THE KOLMOGOROV-IROSHNIKOV (KI) TURBULENCE MODEL?

The Kolmogorov-Iroshnikov (KI) turbulence model is a theoretical framework for describing magnetohydrodynamic (MHD) turbulence, particularly in plasmas and astrophysical flows. It extends Kolmogorov's classical turbulence theory to account for the effects of magnetic fields on turbulent energy cascades. This framework plays a significant role in understanding turbulence in astrophysical environments, such as the solar wind, interstellar medium, and fusion plasmas.

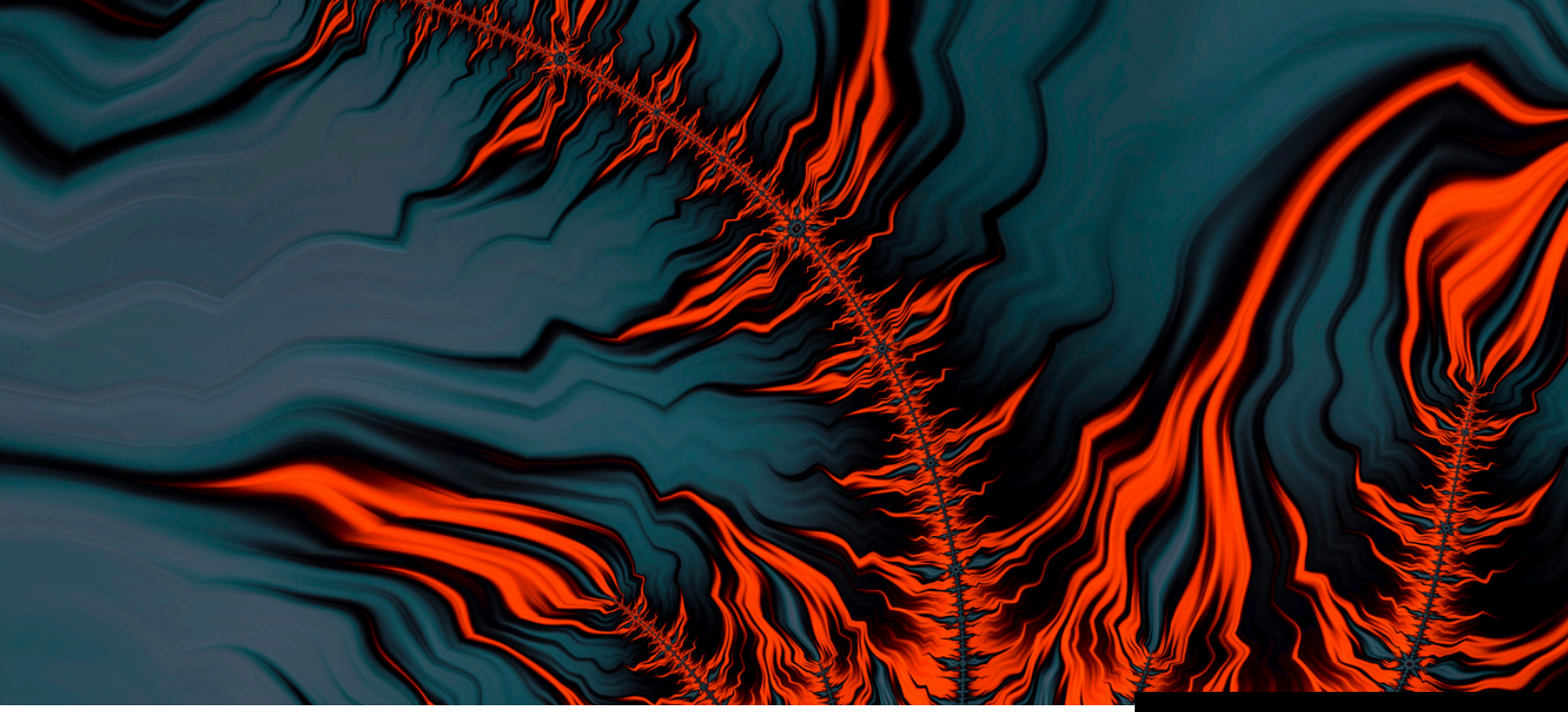
Observations from ground-based magnetometers confirm that the temporal patterns of these fluctuations match those found in space. The study highlights several key frequencies in magnetic variations, including:

DAILY VARIATIONS:
Caused by temperature-driven electric currents in the ionosphere on the sunlit side of Earth.

SEASONAL CYCLES:
Related to changes in solar heating throughout the year.

27-DAY PEAKS:
Corresponding to the Sun's rotation, influencing solar wind patterns that reach Earth.

By better understanding the chaotic but structured nature of magnetic field variations, we get one step closer to predicting these affects more accurately.

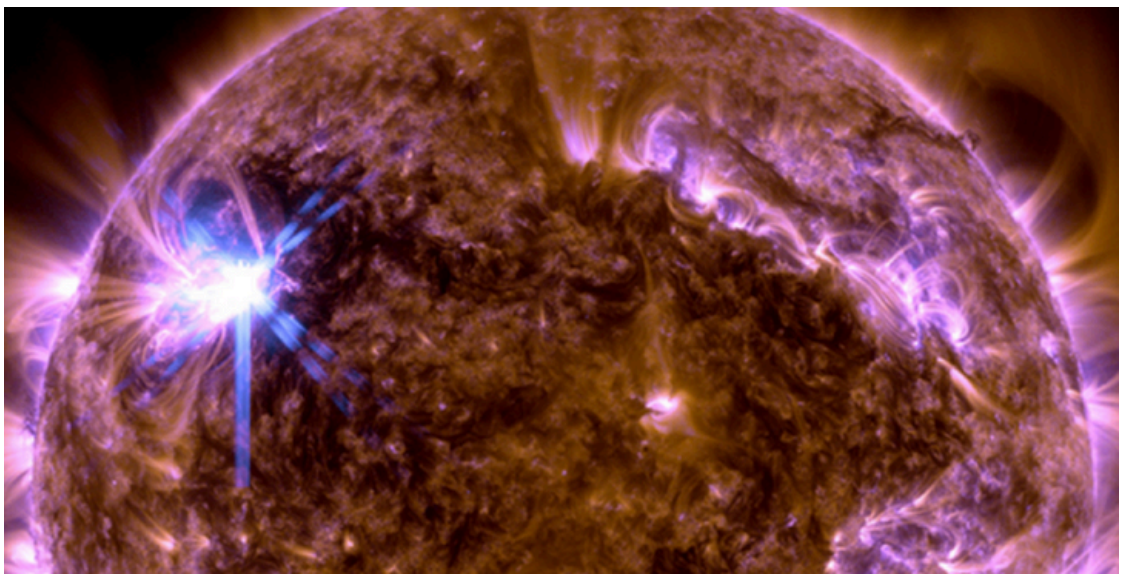


SUPERFLARES AND ELECTRONIC VULNERABILITY

BY: BEN DAVDISON

ARTICLE REFERENCED:
SUN-LIKE STARS PRODUCE SUPERFLARES ROUGHLY ONCE PER CENTURY

ONE OF THE MAJOR TOPICS IN SPACE WEATHER, AND LIKELY ONE OF THE MAIN REASONS MANY OF YOU FOUND OUR VIDEOS AND BOOKS, IS THE CONCERN FOR WHAT THEY CALL THE "SOLAR KILLSHOT". THIS IS A SOLAR STORM SO LARGE THAT THE ELECTROMAGNETIC ENERGY DELIVERED INTO THE EARTH SYSTEM CAUSES AN EMP-LIKE DESTRUCTIVE EVENT ON ALL TECHNOLOGY. COPPER WIRES, TRANSFORMERS, CIRCUITS, GENERATORS, APPLIANCES, DEVICES - PRETTY MUCH EVERYTHING THAT MAKES OUR MODERN WORLD "MODERN".



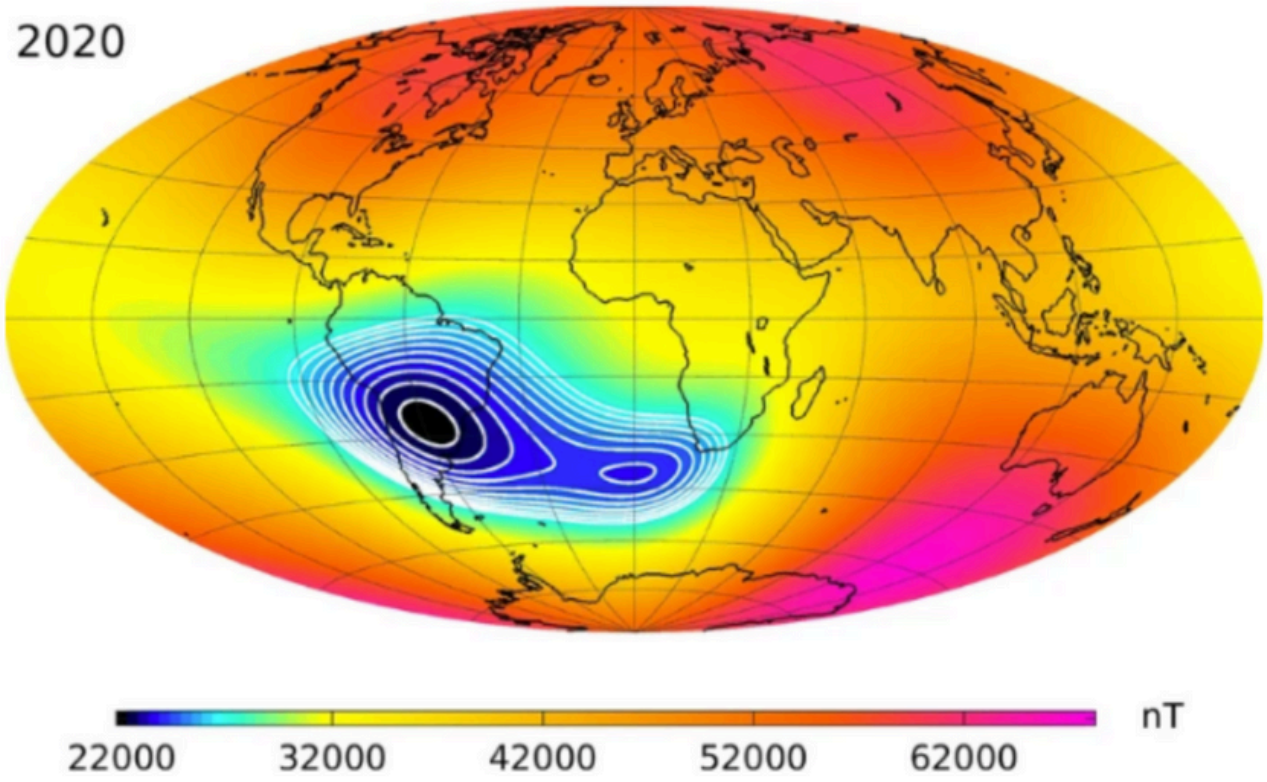
WHAT DOES THE DATA SHOWCASE?

Geologic data suggests that these solar storms hit the earth every 150-200 years, and a new study has come at the question of super-flare frequency on the sun from the other side- the solar physics. This new study suggests that the sun produces one of these major blasts every century, once every 100 years.

Considering that about half of these major flares should be on the half of the sun facing earth and half on the opposite side facing away from earth, that means half those once-a-century solar storms miss our planet, meaning that earth takes a hit every other time, on average, about every 200 years.

THE IMPORTANCE OF THE STUDY

This new study does a good job confirming what the geologic data shows, but more importantly, it tells us that we're getting better at forecasting long-term magnetic activity on the sun. The bad news is that the last one to hit earth was in 1859, so we're in the 150 to 200 years range, and with earth's magnetic field weakening due to the ongoing magnetic pole shift, an even smaller solar storm could have the same effects now.



"Magnetic field intensity map of the South Atlantic Magnetic Anomaly in 2020, showing the weakening of Earth's magnetic field over the region." (2024)

ELECTROMAGNETIC FIELDS AND THE NERVOUS SYSTEM

ARTICLE REFERENCED:

UNVEILING THE BIOLOGICAL EFFECTS OF RADIO-FREQUENCY AND EXTREMELY- LOW FREQUENCY ELECTROMAGNETIC FIELDS ON THE CENTRAL NERVOUS SYSTEM PERFORMANCE

GIVING CONTEXT TO EMF'S

IN THE MODERN ERA, ELECTROMAGNETIC FIELDS (EMF) PLAY A VITAL ROLE IN ENHANCING HUMAN LIFE THROUGH VARIOUS TECHNOLOGIES. HOWEVER, CONTINUOUS EXPOSURE TO EMF, ESPECIALLY FROM RF-EMR AND ELF-EMF SOURCES, HAS RAISED CONCERNS ABOUT THEIR IMPACT ON THE CENTRAL NERVOUS SYSTEM (CNS). THE NERVOUS SYSTEM IS CONSIDERED PARTICULARLY SENSITIVE TO EMF, AND WITH THE WIDESPREAD USE OF MOBILE PHONES AND CELLULAR ANTENNAS, UNDERSTANDING THE INTERACTIONS BETWEEN EMF AND BIOLOGICAL SYSTEMS BECOMES CRUCIAL.

EMF is generated by the motion of electrically charged particles, originating from various sources. EMF can exist in static and dynamic forms, the latter leading to the emergence of electromagnetic radiation (EMR). The EMR spectrum encompasses various frequencies, including radio waves and microwaves, with non-ionizing and ionizing radiations. Studies have focused on the impact of EMR on health, including concerns about electromagnetic hypersensitivity, immune dysfunction, neurological diseases, kidney damage, reproductive disorders, and genetic damage.

The brain, as the regulator of cognitive and behavioral functions, is under scrutiny for its response to RF-EMR exposure. The effects can be categorized into thermal and non-thermal effects. Thermal effects involve the absorption of radiation, leading to increased tissue temperature. Non-thermal effects, such as the pearl chain effect and dielectric saturation, result from forces acting on particles. Studies suggest that RF-EMR exposure may affect metabolic processes, alter calcium channels, cause demyelination, and impact autophagic activities in neurons. The debate continues on non-thermal effects, such as changes in blood-brain barrier permeability, blood pressure, and encephalogram.

The BBB plays a crucial role in maintaining a regulated extracellular environment essential for synaptic transmissions and nerve cell protection. Studies indicate that RF-EMR exposure may induce a transient increase in BBB permeability for macromolecules, with variations depending on operational frequencies and exposure levels. However, conflicting results in the literature warrant further investigation into the potential impact of RF-EMR exposure on blood pressure and its complications.

Neurotransmitters are vital mediators in neuronal communication, influencing cognitive and emotional behaviors. Dopamine, a fundamental neurotransmitter, plays a crucial role in various cerebral functions. Studies indicate potential alterations in neurotransmitter concentrations following RF-EMR exposure, raising concerns about its implications for neurological disorders such as Parkinson's disease and Alzheimer's disease. Concerns about brain development issues caused by RF exposure are significant, particularly in fetuses, infants, children, and adolescents.

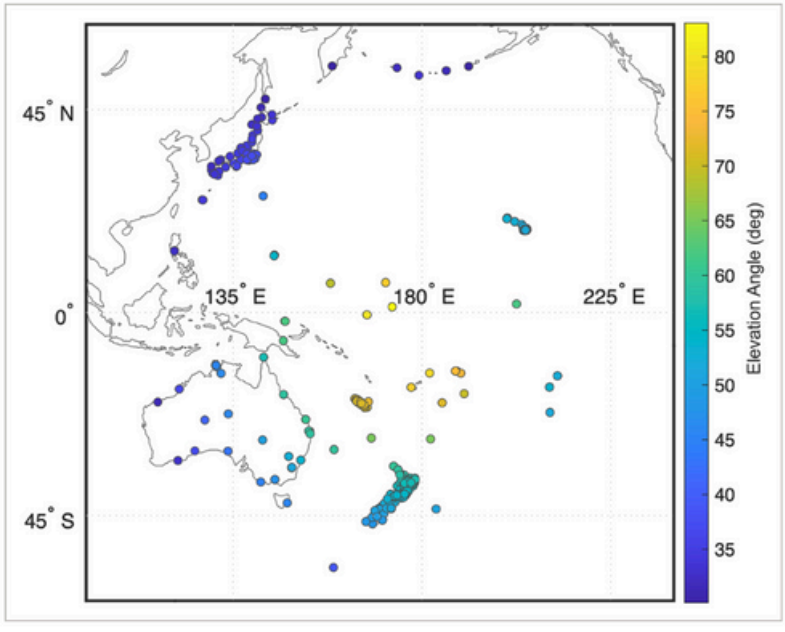
SOLAR TEC PULSES AND COMMUNICATION SYSTEMS

ARTICLE REFERENCED:
QUASI-PERIODIC PULSATIONS IN IONOSPHERIC TEC SYNCHRONIZED WITH SOLAR FLARE EUV EMISSION

New research reveals that Earth's upper atmosphere pulses in sync with solar flare flickers, within seconds. When a solar flare erupts, it unleashes a powerful blast of energy across the electromagnetic spectrum, X-rays, ultraviolet light, and particularly extreme ultraviolet radiation. But a new discovery has added a stunning twist: Earth doesn't just react broadly to solar outbursts—it responds in rhythm.

A study led by Aisling N. O'Hare and colleagues, published in Journal of Geophysical Research: Space Physics (April 2025), has for the first time detected quasi-periodic pulsations (QPPs) in both solar EUV emissions and the Earth's Total Electron Content (TEC), with the two dancing in near-perfect synchronization, only seconds apart.

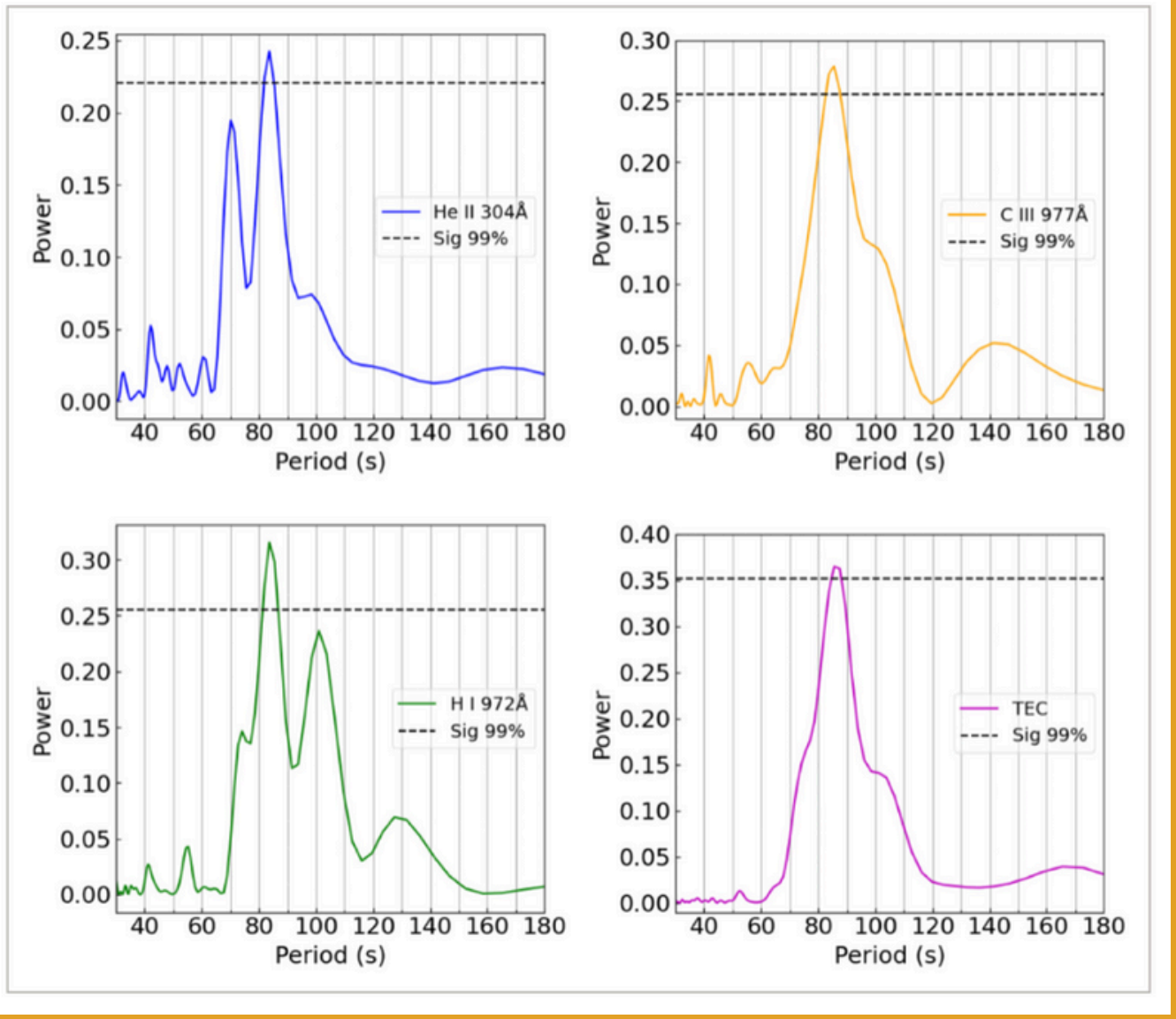
TEC measures the number of electrons between a GPS satellite and a receiver on the ground. It's a crucial indicator of ionospheric activity. When solar radiation increases during flares, more atoms in the upper atmosphere get ionized, meaning more electrons appear, and TEC rises. Changes in TEC can disrupt GPS accuracy, radio signals, and satellite communications, critical systems that modern life depends on. That makes understanding exactly how solar flares modulate TEC a key priority for space weather forecasting.



"MAP SHOWING THE LOCATION OF THE GPS STATIONS OF THE SOPAC NETWORK USED IN THIS STUDY. THE COLOR BAR ILLUSTRATES THE SOLAR ELEVATION ANGLE FROM EACH STATION IN DEGREES."

While X-ray pulsations had previously been linked to Earth's lower ionosphere, it was unclear whether similar fluctuations in EUV light affected the upper layers.

This study focused on an X5.4-class solar flare that erupted on March 7, 2012. By analyzing high-resolution observations from NASA's Solar Dynamics Observatory (SDO) and GPS stations around the globe, the researchers found synchronized pulsations in three EUV wavelengths; He II 304 Å, C III 977 Å, and H I 972 Å. These specific emissions are known to energize the E and F regions of Earth's ionosphere, the very zones responsible for the majority of ionospheric electron content.



"LOMB-SCARGLE PERIODOGRAMS FOR THE THREE EUV EMISSION LINES: HE IL 304 A (BLUE), C III 977 A (ORANGE), H | 972 A (GREEN), AND TEC (MAGENTA). THE DASHED LINES DENOTE THE 99% SIGNIFICANCE LEVEL."

And the match wasn't subtle: TEC pulsations appeared with a delay of just 30 seconds, echoing the Sun's rhythm with striking fidelity.

Why 30 Seconds Later? That short delay isn't arbitrary. It reflects a known property of the ionosphere called "sluggishness"—the time it takes for the atmosphere to respond to sudden changes in solar radiation. It depends on how quickly newly ionized particles are created and how fast they recombine. This lag can now be precisely measured, opening a new window into calculating atmospheric recombination rates—essential for better climate and space weather modeling.

To identify these subtle signals, the researchers used wavelet and periodogram analysis, two statistical tools designed to spot periodic behavior in noisy data. They filtered out the broader trend of the flare to reveal the flickers beneath. The result: clear and consistent pulsations with an average period of 85 seconds, appearing in both the solar EUV light and the ionospheric TEC. The team analyzed data from 251 GPS stations across mid-latitudes, ensuring coverage of the sunlit side of Earth where ionospheric changes are most pronounced. In each case, the rhythmic pattern held.

This discovery adds a poetic dimension to space science: when the Sun pulses, Earth pulses back. Not just in broad sweeps, but in tightly timed oscillations—a conversation unfolding every 85 seconds, across 150 million kilometers.

IT'S A REMINDER THAT EARTH'S SPACE ENVIRONMENT IS NOT A PASSIVE SHIELD, BUT A LIVING, BREATHING SYSTEM ATTUNED TO ITS STAR'S HEARTBEAT. AND AS SOLAR ACTIVITY RAMPS UP DURING THE ONGOING SOLAR CYCLE, THESE FINDINGS WILL HELP US STAY ONE STEP AHEAD OF THE SUN'S NEXT PULSE.

SOLAR FORCING AND ENSO'S TECH REPERCUSSIONS

BY: BAILEY

ARTICLE REFERENCED:
IS THE VARIABILITY OF ENSO DUE TO FREQUENCY MODULATION BY THE LONG TERM VARIATION IN SOLAR ACTIVITY?

When we talk about Earth's climate, few natural patterns hold as much sway as the El Niño-Southern Oscillation, or ENSO. This powerful ocean-atmosphere phenomenon can dramatically influence global temperatures, rainfall, droughts, and even wildfire activity across continents. But one of science's lingering mysteries is why ENSO is so unpredictable — why its strength and frequency seem to change from decade to decade. A new study published in the Journal of Atmospheric and Solar-Terrestrial Physics by Ian Edmonds and Peter Killen proposes an intriguing answer: the variability of ENSO might be frequency modulated by the Sun's long-term activity cycles — a concept borrowed from the world of radio engineering.

WHAT IS ENSO?

ENSO is a natural oscillation between warm (El Niño) and cool (La Niña) phases in the central Pacific Ocean that occurs every 2–7 years. It plays a leading role in shaping seasonal weather patterns around the world.

But when scientists look at the historical record of ENSO — based on both direct observations and proxies like tree rings and coral growth — the picture gets messier. ENSO doesn't hum along at a fixed pace like a metronome. Instead, its timing and intensity shift in a seemingly erratic way, sometimes dominated by 3-year cycles, other times by 11-year or even longer swings.

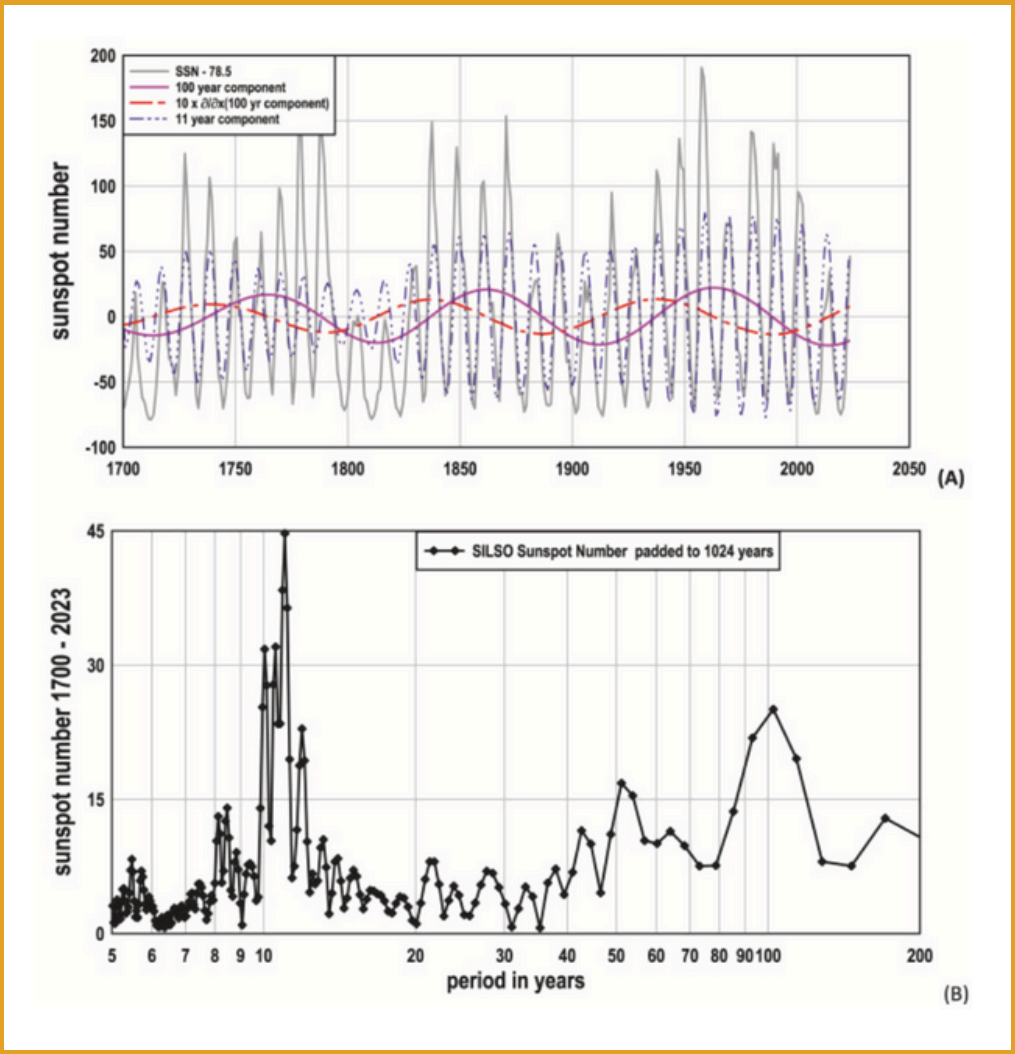
HERE'S WHERE THE CONCEPT FROM COMMUNICATION ENGINEERING COMES IN. IN RADIO BROADCASTING, FREQUENCY MODULATION (FM) IS USED TO ENCODE A SIGNAL BY VARYING THE FREQUENCY OF A WAVE. THIS IS HOW FM RADIO WORKS — IT ALLOWS A STABLE SIGNAL TO CARRY A COMPLEX MESSAGE ACROSS A WIDE RANGE.

WHAT DOES THE STUDY SUGGEST?

Edmonds and Killen suggest that something similar might be happening in the Earth system: the Sun's long-term activity — especially its roughly 100-year Gleissberg cycle — may be subtly "modulating" the frequency of ENSO.This wouldn't change the amplitude of ENSO events (i.e., how strong El Niños and La Niñas are), but rather the spacing between them — just like an FM signal varies the pitch over time.

Past attempts to directly link ENSO to solar amplitude (the amount of solar energy) haven't been very successful. But this study flips the question: What if the Sun isn't turning ENSO up or down, but instead adjusting the tempo at which it plays out?

By modeling ENSO as a kind of climate "oscillator" and applying a frequency modulation using the long-term solar cycle, Edmonds and Killen created a simulation that closely matches real ENSO data over the past 150+ years — especially the decadal components.



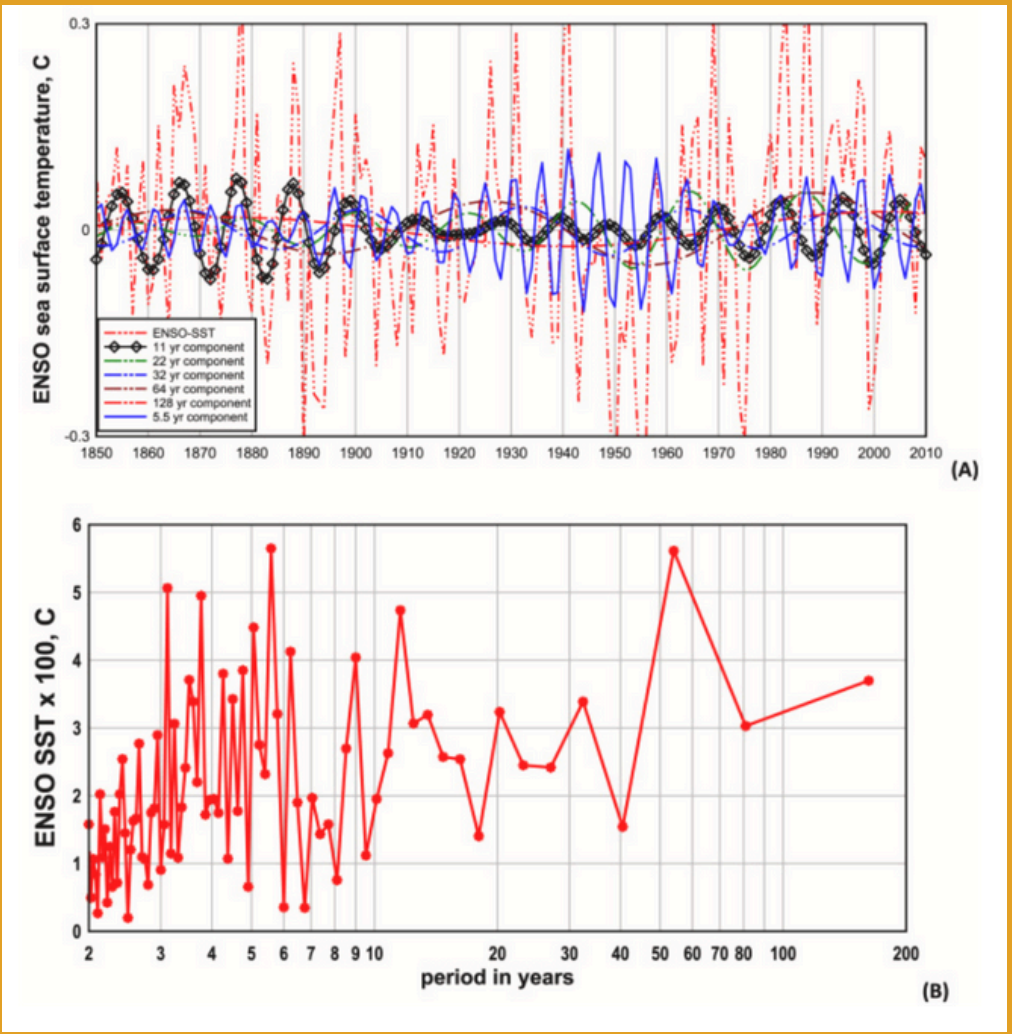
"The ENSO sea surface temperature record 1848 to 2010 and various components obtained by band pass filtering using the INF method. The periodogram of ENSO, obtained by Fourier analysis of the entire 1848–2010 record shows the presence of sub-decadal, decadal and multi-decadal components of roughly equal amplitude in an essentially flat spectrum indicative of either a random noise or frequency modulation characterization of ENSO."

The researchers compared their model not only to sea surface temperature data (a direct proxy for ENSO) but also to global temperature and rainfall records. The results?

- A high correlation between the decadal patterns in the model and ENSO data.
- A moderate match between the model and global temperature variations — which makes sense, since temperature is affected by many other factors too.
- Better fits during time periods (like 1700–present) when long-term solar cycles were more stable, as confirmed by wavelet analysis.

They also used innovative techniques — like applying a double Fourier transform — to extract hidden long-period cycles in climate records, uncovering not just the ~100-year Gleissberg cycle, but also potential ~170-year patterns linked to earlier centuries of solar behavior.

Importantly, it underscores a subtle but powerful idea: climate forcing — like that from the Sun — influences Earth's climate not just by adding heat, but by changing the timing of internal systems like ENSO.



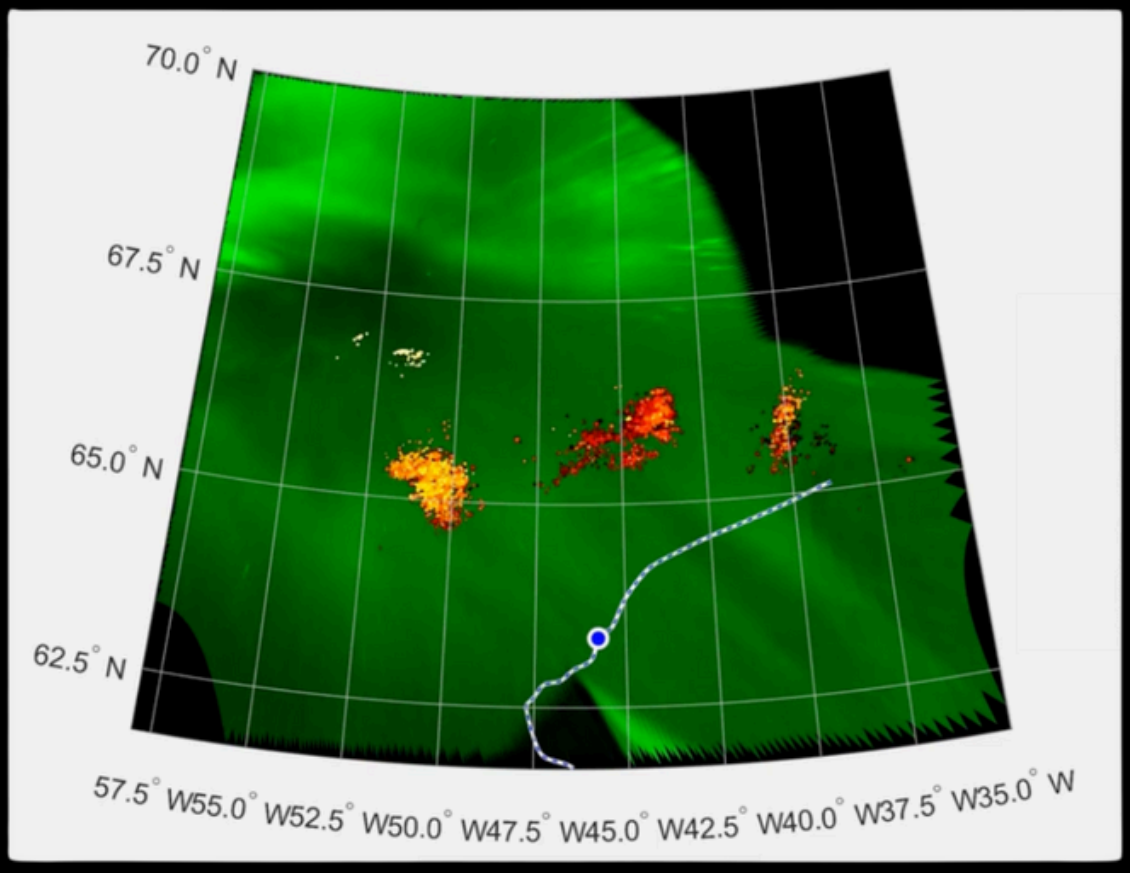
"The average amplitudes of the various components shown are roughly equal and this is also indicated in the periodogram of ENSO, taken over the entire record. The 11 year period component of ENSO dominates in the early part of the record while the 5.5 year period component of ENSO is dominant in the middle of the record suggesting the likelihood of ENSO being frequency modulated.

RAPID ELECTRICAL FORCING FROM SOLAR STORMS

BY; BEN DAVIDSON

ARTICLE REFERENCED:
ATMOSPHERIC TURBULENCE TRIGGERED BY EVENTS 20,000 KM UP

A new study has found a potential connection between turbulence in the Earth's ionosphere (90-150 km above the surface) and events in the magnetosphere, 20,000 km away. Researchers used data from the Arase satellite and the ICEBEAR radar to observe this link, noting electric-field oscillations (0.1–20 kHz) from wave-particle interactions. A significant observation on May 12, 2021, showed a 12-minute radar echo cluster during auroral activity, suggesting these interactions trigger ionospheric turbulence. This could improve predictions for space weather, potentially aiding in forecasting disruptions to radio communications, similar to weather forecasting.



Ionospheric turbulence is signified by radar reflections, or “echoes” (colored dots), detected by ICEBEAR’s radar receiver site near Saskatoon, Canada. During these events, cameras from another facility near Calgary turned on and recorded auroral activity (green, starting partway through the video). The blue–white dashed path depicts the trajectory of the satellite Arase, which was in the magnetosphere.

But there is so much more in play here: This fortifies the concept that solar wind disruptions of the earth's magnetic field impact the layers below, and the ionospheric layer here is the ceiling of the global electric circuit. This is a direct line of evidence for the 100s of papers on electrodynamic solar wind forcing of weather events (which remain ignored in climate models) and shows just how connected our atmosphere actually is to the sun.

THE IMPORTANCE

This forcing was also noted to be very rapid. Most climate models have a 1 to 11 year lag for various UV irradiance forcings, but the "ignored" studies often show rapid forcing on the scale of minutes. This study found dramatic impacts taking place over just a short period of time on one day. I checked - this impact, not just in general, but THIS specific event on May 12, 2025 is currently attributed to human pollution in all climate models.

The Ionospheric Continuous-wave E-region Bistatic Experimental Auroral Radar (ICEBEAR) transmitter site near Leader, Canada, emits radio waves for the purpose of detecting knots of turbulent plasma in the ionosphere. The reflected waves are detected at a separate facility.

THANK YOU!

WE HOPE YOU ENJOYED OUR SPECIAL ISSUE!
WE APPRECIATE YOUR QUEST AND LOVE FOR KNOWLEDGE ABOUT SPACE AND OUR GREATER COSMOS.

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Email observerreview@observerranch.com with a topic that you'd love to see an article written on!